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CHAPTER 1

INTRODUCTION

1.1 GENERAL

This *Manual* has been developed to provide information and guidance to engineering staffs involved with project development and design of highways. It will identify those standards, specifications, guides and references approved for use in carrying out the highway and bridge design responsibilities in the Federal Lands Highway (FLH) Program.

One primary goal of the FLH Program is to design safe, cost-effective and environmentally sound highways and roads to serve our nation's Federal Lands. To assist in achieving this goal, the *Project Development and Design Manual* (PDDM) has been developed.

The *Manual* supplements Federal laws and regulations relative to the development and design of highways. It is intended to be used with current engineering practices and procedures issued by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), State highway agencies and Federal Land Management agencies.

1.1.1 Background

Approximately one-third of the total land area of the United States is owned or controlled by the Federal government. One of the world's largest highway networks has been constructed to serve these Federal lands.

Several Federal agencies are responsible for managing public lands and consequently are also responsible for managing a part of this vast network of Federal roads. The role of the Federal Highway Administration (FHWA) and its Federal Lands Highway Office (FLHO) in designing and constructing highway facilities on Federal lands is well defined in existing legislation and supplemental National interagency agreements.

In 1893, legislation established the Office of Road Inquiry within the Department of Agriculture. This Office was not initially created to build highways but to provide the lead in research and development of new methods and techniques for road construction. Assistance and technical information were provided by the local and State agencies responsible for road construction. However, short demonstration projects approximately 0.4 km (0.25 mi) in length and called object lesson roads were built by FLH forces to promote the most recent technology of the time for the construction of surfaced, all-weather roads.

In 1905, the Office of Road Inquiry became the Office of Public Roads. In 1918, the Office became the Bureau of Public Roads and in 1967 it became the Federal Highway Administration (FHWA).

In 1982, the *Surface Transportation Assistance Act* (STAA) created the FLH Program. The STAA annually authorized, out of the Highway Trust Fund, \$250 million in fiscal year (FY) 1983

and \$300 million in each FY from 1984 through 1986. With the initiation of this Program came increased responsibility for the FLH Program to assist the Federal land managing agencies in the application of uniform policies for highway planning, design, construction, maintenance and safety.

In 1987, the *Surface Transportation and Uniform Relocation Assistance Act* was enacted. It continued the FLH Program but reduced the FY authorizations from the previous \$300 million to \$235 million. This *Act* provided funding for highways from FY 87 through FY 91. The *Intermodal Surface Transportation Efficiency Act* (ISTEA) of 1991 extended the FLH Program through FY 97. The *Act* authorized funding of \$371 million in FY 92, \$445 million in FY 93 through FY 95, and \$447 million in FY 96 and FY 97. The Public Lands Highway category under the *Act* incorporates the previous Forest Highway category. Within this *Manual*, Forest Highways and Public Lands Highways are used interchangeably.

In 1986, the Department of Transportation (DOT) approved the reorganization of the Office of Direct Federal Programs within FHWA to become the Federal Lands Highway Office (FLHO). This Office administers the FLH Program, the Emergency Relief Program on Federally owned roads and the Defense Access Road Program. It also administers training and development programs and provides engineering services to other Federal and State agencies and foreign countries. See [Exhibit 1.1-A](#) for a geographical breakdown of Federal Lands Highway Division offices.

For more than 100 years, FLHO and its predecessor offices have offered their expertise to other government agencies for the planning, location, design and construction of highways, parkways, roads and trails in the Federal domain. Many foreign countries have also been assisted in the development and construction of road systems.

1.1.2 Format

This *Manual* consists of 11 chapters in electronic form. Generally, each chapter is located in a separate electronic file in a format compatible with Microsoft Word. (Note: Due to the large file space required by graphical CADD Exhibits in [Chapters Six](#) and [Nine](#), they are located separately in each Division's CADD system in MicroStation format.) Each chapter has its own table of contents and is subdivided into sections. The last section in each chapter has been reserved for special Division office supplemental procedures. Division procedures may be separate (i.e., hard copy or electronic files).

This *Manual* is published in SI (metric) units followed by U.S. Customary (English) units in parenthesis. An exact conversion may not be shown, and the equivalent units may be rounded.

1.1.3 Revisions

FLHO is responsible for maintaining the *Manual*. Periodically, selected chapters will be reviewed for adequacy and to determine if there is need for revisions. Policy changes and new technology will also require chapters to be revised.

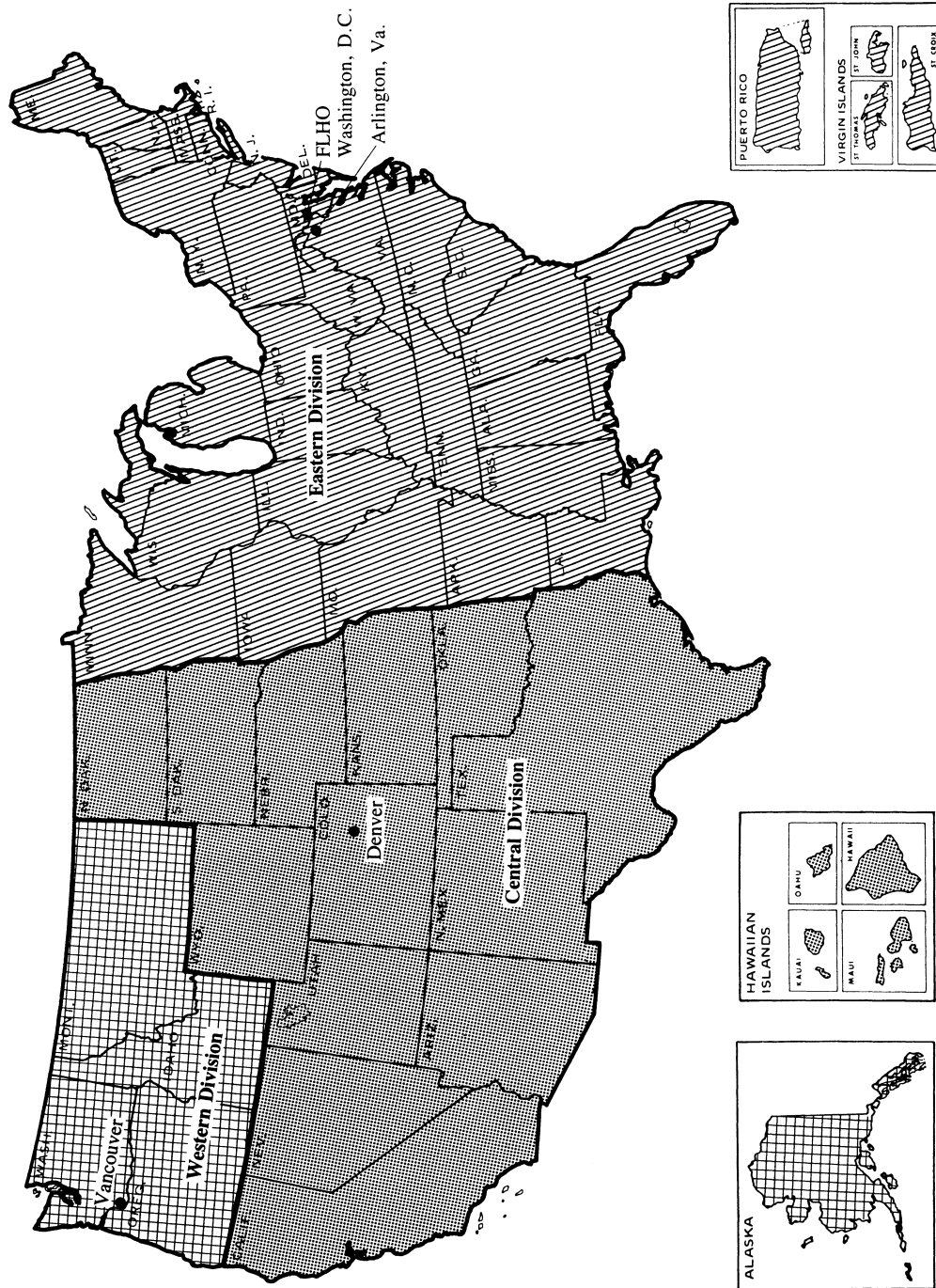


Exhibit 1.1-A FEDERAL LANDS HIGHWAY DIVISION BOUNDARIES

When updating information in the *Manual*, use the following process:

1. The FLHO or a Division office, or a Functional Discipline Team, may propose revisions at any time. Division Offices or Functional Discipline Teams must submit their proposal to FLHO for consideration. If FLHO determines the *Manual* should be revised, it will make the revisions or work with the Divisions or Functional Discipline Teams to have the preparatory work be done by consultant or the Division offices staff.
2. Once revised, the FLHO will distribute copies to each Division, requesting comments. When appropriate, comments may also be requested from other FHWA offices and from private industry.
3. The FLHO will approve and issue revisions after resolving any comments. If revisions are minor or not controversial, FLHO may approve and issue revisions without distribution for comments.
4. All changes to the *Manual* chapters and sections (except sections reserved for Division procedures) must be issued by FLHO. Each revision must be distributed by a sequentially numbered transmittal memorandum. Transmittal Memorandum Number 7 transmitted the 1996 metric version of *Manual* [Chapters 1 through 11](#).
5. The revisions will be provided electronically. No hard copies will normally be included. Revisions must be of a type style as the original *Manual*. The revised file must be identified by including the revision date at the top of each page. In addition, a history of Transmittals will be provided as a separate file to ensure users have all previous revisions available.

FLHO will be responsible for distribution to other FHWA offices and partner agencies. Each FLH Division is responsible for the availability of the *Manual* and supplements within their jurisdiction.

Distributing and updating the *PDDM* is done by providing the most up-to-date file or files on the Internet. This should minimize distribution difficulties with outside users (e.g., A/E firms, other Federal agencies).

It is the responsibility of each Division to develop a process to ensure availability of revisions that need to be included in manuals being held by A/E firms working on active contracts.

1.1.4 Division Procedures

Supplements added to the section reserved for Federal Lands Highway Division procedures must be issued by the appropriate office in a compatible format. The electronic versions should be identified by the following Divisions reference at the bottom of each page:

- Eastern Federal Lands Highway Division (EFLHD).
- Central Federal Lands Highway Division (CFLHD).
- Western Federal Lands Highway Division (WFLHD).

Informational electronic copies of Division supplements must be provided to the other Division offices and FLHO on a routine basis upon issuance.

Each user of this *Manual* may contribute to its continuing improvement and is encouraged to submit suggestions to provide a more useful and practical document.

1.2 GUIDANCE AND REFERENCES

Applicable laws are set forth in [Title 23, United States Code \(USC\)](#). The governing regulations are found in [Title 23, Code of Federal Regulations \(CFR\)](#). Policies and guidelines are contained in the [Federal-aid Policy Guide \(FAPG\)](#), the *Federal Lands Highway Manual (FLHM)*, National and project interagency agreements and AASHTO or other recognized publications.

1.2.1 ***Code of Federal Regulations (CFR)***

The *Code of Federal Regulations* is a codification of the general and permanent rules published in the *Federal Register* by agencies of the Federal government. The Code is divided into 50 titles representing broad areas of Federal regulations. Title 23, CFR – “Highways,” represents the current regulations applicable to the FHWA and the FLH Program. The following are the parts of 23 CFR that are most relevant to the development and design of highways:

- Part 620, Subpart A – Highway Improvements in the Vicinity of Airports.
- Part 625 – Design Standards for Highways.
- Part 630 – Preconstruction Procedures.
- Part 650 – Bridges, Structures and Hydraulics.
- Part 652 – Pedestrian and Bicycle Accommodations and Projects.
- Part 655 – Traffic Operations.
- Part 660 – Special Programs (Direct Federal) Forest Highways and Defense Access Roads.
- Part 668, Subpart B – Emergency Relief Program Procedures for Federal Agencies for Federal Roads.
- Part 752 – Landscape and Roadside Development.
- Part 771 – Environmental Impact and Related Procedures.
- Part 772 – Procedures for Abatement of Highway Traffic Noise and Construction Noise.

1.2.2 **[Federal-Aid Policy Guide \(FAPG\)](#)**

The *FAPG* consists of two volumes containing FHWA’s current policies, procedures, standards and guides relating to the Federal-Aid Highway Program. The *Manual* also contains program directives relative to administration of the FLH Program.

1.2.3 Federal Lands Highway Manual (FLHM)

The *Manual* is a one-volume book of documents developed by the Federal Lands Highway Office to consolidate all basic policies, directives, standards and guides pertaining to the Federal Lands Highway operations into a single resource publication for ease of use and reference.

1.2.4 National Interagency and Project Agreements

Agency agreements are required whenever FHWA performs work for another agency or when work is performed by another agency with funds administered by FHWA. National agreements have been executed between FHWA and principal Federal land management agencies (i.e., National Park Service (NPS), Forest Service (FS), Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM)). Project agreements are executed between Division offices and another agency to detail project specifics that cannot be covered by a National agreement (e.g., project funding, length, geometrics, right-of-way acquisition, utility relocation, construction) and maintenance responsibilities. Agreements are discussed in [Chapter Two](#).

1.2.5 AASHTO Policy and Guides

American Association of State Highway and Transportation Officials (AASHTO) was organized in 1914 and is composed of representatives from all 50 State highway transportation departments, the Commonwealth of Puerto Rico and the Northern Mariana Islands, the District of Columbia, six Canadian Provinces and two Territories and the Federal Highway Administration.

The organization brought together Federal, State and other highway engineers for discussion of problems, planning of concerted action and adoption of uniform practices. Its objective is to foster the development, operation and maintenance of a nationwide integrated system of highways to adequately serve the transportation needs of our country.

AASHTO publishes specifications, guides and standards on highway design and construction that generally prescribe good practices or criteria considered adequate to provide safe and cost-effective highway facilities. These approved standards and guides as listed herein are to be used in conjunction with this *Manual*. Design standards for highways are listed in [Part 625 of 23 CFR](#).

1.2.6 Other Guides

Other acceptable guides and publications may be referenced in specific chapters. Publications referenced in this *Manual* are available for use within in each Division office.

1.2.7 References

The following publications provided much of the fundamental source information used in the development of this *Manual*. Additional reference documents may also be identified in individual chapters.

1. *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, (FP-XX), DOT, FHWA, current ed.
2. [*Park Road Standards*](#), US Department of the Interior, National Park Service, 1984.
3. *Standard Highway Alphabet*, DOT, FHWA, current ed.
4. [*Standard Highway Signs*](#), DOT, FHWA, current ed.
5. *Traffic Control Devices Handbook*, ITE, current ed.
6. [*Manual on Uniform Traffic Control Devices for Streets and Highways \(MUTCD\)*](#), DOT, FHWA, current ed.
7. *A Policy on Geometric Design of Highways and Streets* (generally called the *Green Book*), AASHTO, current ed.
8. *Roadside Design Guide*, AASHTO, current ed.
9. [*Designing Safer Roads, Practices for Resurfacing, Restoration and Rehabilitation*](#), Special Report 214, TRB, 1987.
10. *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, AASHTO, current ed.
11. *Materials Manual*, Parts I and II, AASHTO, current ed.

1.3 LAND MANAGEMENT AGENCIES

Land management agencies are Federal agencies established under laws and regulations and delegated the authority to administer and manage the vast National resources on Federally owned or controlled lands within the United States and its territories. They have the responsibility for constructing and maintaining a public roads system within these lands.

The four principal land management agencies involved with the Federal Lands Highway Program are as follows:

- National Park Service (NPS),
- Forest Service (FS),
- Bureau of Indian Affairs (BIA), and
- US Fish and Wildlife Service (USF&WS).

The FLHO also works on a smaller scale with other Federal and State government agencies upon request.

FLH's mission when working with these land management agencies typically entails all phases of project development and design. The legal authorization permitting the FLHO to design and construct highways serving Federal lands is contained in [23 USC 202, 204 and 308](#).

1.3.1 National Park Service (NPS)

NPS is an agency of the US Department of Interior responsible for presiding over all national parklands, recreational areas, monuments, military parks, historical sites, seashores, lakeshores and parkways.

The national park system encompasses more than 8.7 million hectares (21.5 million acres) of Federal lands that are noted for their scenic beauty or historical significance. The system contains some 13,000 km (8,000 mi) of park roads and parkways.

Under the authority prescribed in [23 USC 202, 204 and 308](#) and in the Memorandum of Agreement between NPS and FHWA, the procedures are established defining responsibilities of each organization relative to the project development and construction of park roads and parkways. See [FAPG G6090.13](#).

1.3.2 Forest Service (FS)

FS is an agency of the US Department of Agriculture whose primary responsibility is the protection and multiple use management of land and resources within the National Forest System as set forth in the *National Forest Management Act* of 1976 (16 USC 1609).

The National Forest System contains approximately 39,000 km (24,000 mi) of Forest Highways and 500,000 km (311,000 mi) of Forest Development Roads (FDR) with some 48,000 km (30,000 mi) of these FDR's maintained for public passenger car use.

Under the authority prescribed in [23 CFR 660](#) and in the Memorandum of Understanding executed between FS and FHWA, the procedures are established for coordinating project development applicable to Public Lands Highways.

[Title 23 USC 308](#) establishes the foundation for FHWA's participation in the location, design and/or construction of forest development roads and trails when these activities are requested by the Forest Service.

1.3.3 Bureau of Indian Affairs (BIA)

BIA is an agency of the US Department of the Interior with the primary responsibility for constructing and maintaining a system of public roads located within or providing access to an Indian reservation, Indian trust land or restricted Indian land, which is not subject to fee title alienation without the approval of the Federal government. The system includes approximately 39,000 km (24,000 mi) of roads.

Under the authority prescribed in [Title 23 USC 204 and 308](#), and in the Memorandum of Agreement between BIA and FHWA, the Federal Lands Highway Divisions may perform any or all phases of project development as set forth in individual project agreements executed between BIA and the appropriate Division. See [FAPG G6090.17](#).

1.3.4 US Fish & Wildlife Service (USF&WS) Refuge Roads

USF&WS is an agency in the US Department of Interior. The National Wildlife Refuge System comprises over 38 million hectares (95 million acres), with more than 535 refuges and thousands of small prairie wetlands that serve as waterfowl breeding and nesting areas.

Refuge roads are public roads that provide access to or within a unit of the National Wildlife Refuge System and ownership and maintenance responsibility are the Federal government's. In order to be considered Public Roads, refuge roads must be opened to the general public during substantial parts of the year.

Refuge road funds may only be used for resurfacing, restoration, and rehabilitation (RRR) to extend the service life of an existing road and enhance safety. RRR work includes the placement of additional surfacing materials and/or other work necessary to return an existing roadway including shoulders, the roadside, and appurtenances, to a condition of structural adequacy. Construction of new roads is not authorized. Refuge road projects generally will not involve widening beyond the existing road bench or require the construction of new retaining walls, or cuts and fills. Exceptions where work could occur off of the road bench include work on drainage structures, existing retaining walls, slope failures, bridges, and spot traffic safety improvement work. Eligible structural work includes approach fill rehabilitation, superstructure replacements, abutment and foundation repairs, abutment slope protection, foundation scour repair and protection work, and piling replacements. Small bridges or large box culverts may be replaced if the estimated cost for a replacement structure is \$500,000 or less.

Because it is a RRR program and designers will be required to stay within the existing roadway prism, design standards for new construction and re-construction are typically not applicable. Since FWS has not developed 3-R design criteria, AASHTO design criteria should be the basis

for development of design exceptions where traffic safety experience does not warrant improvements to full design criteria. Achievement of AASHTO standards usually will not be possible without demonstrated and documented safety deficiencies.

1.3.5 Other Agencies

In addition to the primary land management agencies, FHWA, when requested, cooperates and works with other Federal agencies (e.g., the Department of Defense, Federal Aviation Administration, Metropolitan Washington Airports Authority, Federal Railroad Administration, US Army Corps of Engineers, Bonneville Power Administration, Bureau of Land Management, Immigration and Naturalization Service).

FHWA also provides assistance to State agencies as well as to the FHWA-owned Turner Fairbank Highway Research facility in McLean, Virginia on an as-requested basis.

1.4 GLOSSARY

1.4.1 Abbreviations

Whenever these abbreviations are used, they will have the following meaning:

1. **AA.** Aluminum Association.
2. **AASHTO.** American Association of State Highway and Transportation Officials.
3. **ACHP.** Advisory Council on Historic Preservation.
4. **ACI.** American Concrete Institute.
5. **ACSM.** American Congress on Surveying and Mapping.
6. **ADT.** Average Daily Traffic.
7. **AISI.** American Iron and Steel Institute.
8. **APC.** Action Plan Committee.
9. **ARTBA.** American Road and Transportation Builders Association.
10. **ASA.** American Standards Association.
11. **ASCE.** American Society of Civil Engineers.
12. **ASLA.** American Society of Landscape Architects.
13. **ASP.** American Society of Photogrammetry.
14. **ASTM.** American Society for Testing and Materials.
15. **AWPA.** American Wood Preservative Association.
16. **AWS.** American Welding Society.
17. **BIA.** Bureau of Indian Affairs.
18. **BLM.** Bureau of Land Management.
19. **BMPs.** Best Management Practices.
20. **CADD.** Computer Aided Design and Drafting.
21. **CE.** Categorical Exclusion.
22. **CEQ.** Council on Environmental Quality.
23. **CFLHD.** Central Federal Lands Highway Division.

24. **CFR.** *Code of Federal Regulations.*
25. **DHV.** Design Hourly Volume.
26. **DOI.** Department of the Interior.
27. **DOT.** Department of Transportation.
28. **DTM.** Digital Terrain Model.
29. **EA.** Environmental Assessment.
30. **EDM.** Electronic Distance Measuring.
31. **EFLHD.** Eastern Federal Lands Highway Division
32. **EIS.** Environmental Impact Statement.
33. **EPA.** Environmental Protection Agency.
34. **ERFO.** Emergency Relief Federally Owned Programs.
35. **FAA.** Federal Aviation Administration.
36. **FAR.** *Federal Acquisition Regulations.*
37. **FEMA.** Federal Emergency Management Agency.
38. **FHWA.** Federal Highway Administration.
39. **FLHO.** Federal Lands Highway Office.
40. **FONSI.** Finding of No Significant Impact.
41. **FP-XX.** *Book of Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects* (The year of issuance 19XX or 20XX).
42. **FS.** Forest Service.
43. **FWS.** Fish and Wildlife Service.
44. **GEOPAK.** Software program for IHDS.
45. **HUD.** Housing and Urban Development.
46. **IHDS.** Interactive Highway Design System.
47. **IRR.** Indian Reservation Road.
48. **MUTCD.** *Manual on Uniform Traffic Control Devices* for Streets and Highways.
49. **MWAA.** Metropolitan Washington Airports Authority.

50. **NBS.** National Bureau of Standards.
51. **NCHRP.** National Cooperative Highway Research Program.
52. **NEPA.** *National Environmental Policy Act.*
53. **NGS.** National Geodetic Survey.
54. **NHTSA.** National Highway Traffic Safety Administration.
55. **NMFS.** National Marine Fishery Service.
56. **NOAA.** National Oceanic and Atmospheric Administration.
57. **NPS.** National Park Service.
58. **NRCS.** Natural Resources Conservation Service.
59. **OCZM.** Office of Coastal Zone Management.
60. **OSHA.** Occupational Safety and Health Administration.
61. **PCA.** Portland Cement Association.
62. **PCI.** Prestressed Concrete Institute.
63. **PRES.** Parkwide Road Engineering Studies.
64. **PRMS.** Program and Resource Management System.
65. **PS&E.** Plans, Specifications and Estimates.
66. **RDG.** *Roadside Design Guide*, AASHTO, 1988.
67. **RDS.** Roadway Design System.
68. **ROD.** Record of Decision.
69. **RRR.** Resurfacing, Restoration and Rehabilitation.
70. **SCS.** Natural Resources Conservation Service (Former Soil Conservation Service).
71. **SEE.** Social, Economic and Environmental.
72. **SHA.** State Highway Agency.
73. **SHPO.** State Historic Preservation Office.
74. **SNRA.** State Natural Resources Agency.
75. **SSPC.** Steel Structures Painting Council.

- 76. **TAM.** *Department of Transportation Acquisition Manual.*
- 77. **TAR.** *Department of Transportation Acquisition Regulations.*
- 78. **TCP.** Traffic Control Plan.
- 79. **USC.** *United States Code.*
- 80. **UMTA.** Urban Mass Transportation Administration.
- 81. **USACE.** United States Army Corps of Engineers.
- 82. **USCG.** United States Coast Guard.
- 83. **USDA.** United States Department of Agriculture.
- 84. **VPH.** Vehicles per Hour.
- 85. **WFLHD.** Western Federal Lands Highway Division.

1.4.2 Definitions

The following terms are used throughout this *Manual*.

- 1. **Acceleration Lane.** A speed change lane to enable a vehicle entering a roadway to increase its speed to merge with through traffic.
- 2. **Accuracy.** The degree of agreement between a measured value and its established true value.
- 3. **Aeolian Deposits.** Wind-deposited material (e.g., dune sands, loess deposits).
- 4. **Aesthetics.** A branch of philosophy dealing with beauty and the beautiful and judgments of taste concerning them. In highway engineering, aesthetic judgments have to do primarily with the highway as a whole and the roadsides, and includes screening out unpleasant views.
- 5. **Aggradation.** General and progressive raising of the streambed by deposition of sediment.
- 6. **Alkalinity.** The degree of strength of an alkali. A liquid is said to be alkaline if it has a pH factor greater than seven.
- 7. **Alluvial.** Deposits of alluvium (e.g., silts, sands, gravels, similar material that has been transported by running water).
- 8. **Alternating Bars.** Alternating bars tend to be distributed periodically along a channel, with alternate bars near opposite channel banks. Their lateral extent is significantly less than the channel width. Alternating bars move slowly downstream.

9. **Anabran**. A diverging branch of a river that re-enters the main stream.
10. **Angle of Internal Friction**. The angle whose tangent is the ratio between the resistances offered to slide along any plane in the soil and the component of the applied force acting normal to that plane. Values are given in degrees.
11. **Angle of Repose**. The angle between the horizontal and the maximum slope that a soil assumes through natural processes.
12. **Anhydrous**. Free from water.
13. **Annual Flood**. The highest peak discharge in a water year.
14. **Arbitrary Coordinate System**. A system of coordinates based upon an arbitrarily chosen origin. Used when established coordinate systems are not available. Sometimes called assumed coordinate system.
15. **Architectural Features**. As used in roadside enhancement, these may include stepped retaining walls to minimize the visual impact of massive walls, rock sculpturing to blend disturbed areas into the natural terrain, and special treatment of bridge abutments and culvert headwalls to blend them into the landscape.
16. **Area-Capacity Curve**. A graph showing the relation between the surface area of the water in a reservoir and the corresponding volume.
17. **Auxiliary Lane**. The portion of the roadway adjoining the traveled way for weaving, truck climbing, speed changing or for other purposes supplementary to through-traffic movement.
18. **Average Daily Traffic (ADT XXXX)**. (1) The current or projected average two-way daily traffic for a specified year. (2) (ADT YY) The projected average two-way daily traffic for a specified future period, usually 20 years.
19. **Average Discharge**. In the annual series of the geological survey's reports on surface-water supply, the arithmetic average of all complete water years of record whether or not they are consecutive.
20. **Average Highway Speed**. The weighted average of the design speeds within a highway section when each subsection within the section is considered to have an individual design speed.
21. **Average Initial Horizontal Illuminance**. The average level of horizontal illuminance in the pavement area of a traveled way at the time the lighting system is installed, when lamps are new and luminaires are clean. This level is expressed in lux (lumens per square meter (foot) of horizontal surface).
22. **Backfill**. Material used to replace, or the act of replacing material removed during construction; also denotes material placed or the act of placing material adjacent to structures.
23. **Backslope**. In cuts, the slope from the bottom of the ditch to the top of the cut.

24. **Backwater.** Water backed up or retarded in its course as compared with its normal or natural condition of flow. In stream gaging, a rise in stage produced by a temporary obstruction (e.g., ice, weeds) or by the flooding of the stream below. The difference between the observed stage and that, which is indicated by the stage discharge relation, is reported as backwater.
25. **Bankfull Stage.** Stage at which a stream first overflows its natural banks.
26. **Bars.** Bed forms having lengths of the same order as the channel width or greater, and heights comparable to the mean depth of the generating flow.
27. **Bars, Transverse.** Transverse bars occupy nearly the full channel width. They occur both as isolated and as periodic forms along a channel, and move slowly downstream.
28. **Bars, Tributary.** Tributary bars occur immediately downstream from points of lateral inflow into a channel. In longitudinal sections, bars are approximately triangular, with long gentle upstream slopes and short downstream slopes that are approximately the same as the angle of repose of the bed material. Bars generated by high flows frequently appear as small islands during low flows. Parts of the upstream slopes of bars are often covered with ripples or dunes.
29. **Base Course.** The layer, or layers, of specified or selected material of designed thickness placed on a subbase or a subgrade to support a surface course.
30. **Base Discharge.** In the Geological Survey's annual reports on surface-water supply, the discharge above which peak discharge data are published. The base discharge at each station is selected so that an average of about three peaks a year will be presented.
31. **Base Runoff.** Sustained or fair-weather runoff. In most streams, base runoff is composed largely of groundwater effluent. The term base flow is often used in the same sense as base runoff.
32. **Basic Capacity.** The maximum number of passenger cars that can pass a given point on a lane or roadway during one hour under the most nearly ideal roadway and traffic conditions that can be attained.
33. **Basic Hydrologic Data.** Includes inventories of features of land and water that vary only from place-to-place (e.g., topographic map, geologic map), and records that vary with both place and time (e.g., records of precipitation, streamflow, groundwater, quality-of-water analyses.) Basic hydrologic information is a broader term that includes surveys of the water resources of particular areas and a study of their physical and related economic processes, interrelations and mechanisms.
34. **Bed Load.** Sediment that moves by rolling, sliding or skipping along the bed and is essentially in contact with the streambed.
35. **Bedrock.** Rock of relatively great thickness and extent in situ.

36. **Bench Mark.** A temporary or permanent marker of known elevation with reference to a specific datum plane.
37. **Bore (Hydraulic Bore).** A wave of water having a nearly vertical front (e.g., a tidal wave; a wave advancing downstream as the results of a cloudburst, the sudden release of a large volume of water as from a reservoir).
38. **Braided Stream.** A stream in which flow is divided as normal stage by small midchannel bars or small islands. This type of stream has the aspect of a single large channel within which there are subordinate channels.
39. **Brake Reaction Distance.** The distance traversed by the vehicle from the instant the driver sights an object necessitating a stop to the instant the brakes are applied.
40. **Braking Distance.** The distance required to stop the vehicle from the instant brake application begins.
41. **Breakaway (Yielding) Supports.** A support for a roadside device that yields or collapses readily when struck by a vehicle.
42. **Bridge.** A single or multiple span structure, including supports, erected over a depression or an obstruction (e.g., water, highway, railway) and having an opening measured along the center of the roadbed of more than 6 m (20 ft).
43. **Broken Back Curve.** An arrangement of curves in which a short tangent separates two curves in the same direction.
44. **Bypass.** A highway that permits traffic to avoid part or all of an urban area.
45. **Cadastral.** Pertaining to extent, value and ownership of land. Cadastral maps show property corners and property boundaries.
46. **Cadastral Survey.** A survey made to determine the lengths and directions of boundary lines and the area of land bounded by these lines. It may also be a survey made to establish these boundary lines on the ground. Also known as a Property Survey.
47. **Calcareous.** Material containing or similar to calcium carbonate or lime.
48. **Calendar Day.** Any day shown on the calendar, beginning and ending at midnight.
49. **California Bearing Ratio (CBR).** The ratio of the force required to penetrate a soil mass with a circular piston to the force required to penetrate a mass of high quality crushed stone with the same piston. The rate of penetration in both cases is identical.
50. **Camber.** A slight arch designed or built into a structure to compensate for the natural deflection after loading.
51. **Candela (cd).** The unit of luminous intensity.

52. **Capillary Moisture.** Moisture that clings to soil particles by surface tension and reaches the particles by surface tension either when free water passes through the soil or by capillary attraction from a wetter stratum. Within limits, it can move in any direction.
53. **Centerline.** For a two-lane highway the centerline is the middle of the traveled way, and for a divided highway the centerline may be the center of the median. For a divided highway with independent roadways, each roadway has its own centerline.
54. **Channel (Watercourse).** An open conduit either naturally or artificially created that periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, anabranch and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided. Canal and floodway are some of the terms used to described artificial channels.
55. **Channel Stabilization.** Protections of open channels from excessive erosion and scour by channel lining.
- Linings may be flexible (e.g., rock riprap, vegetation, of rigid concrete).
56. **Channel Storage.** The volume of water at a given time in the channel or over the floodplain of the streams in a drainage basin or river reach. Channel storage is great during the progress of a flood event.
57. **Channelization.** The separation of traffic flow into definite paths, by means of traffic markings or islands.
58. **Channelized Intersection.** A grade intersection where traffic is directed into definite paths by islands.
59. **Check-Dam.** A structure usually made of sod, rock or stone, and placed in a watercourse to retard water flow, thereby, reducing erosion.
60. **Chute.** A steep, inclined open channel (flume).
61. **Clay.** A fine-textured soil, usually plastic and sticky when wet, which usually breaks into hard lumps when dry. When the moist soil is pinched between the thumb and finger, it will form a long, flexible ribbon.
62. **Clear Zone.** That area along the side of the traveled way (including the shoulder) that is available for recovery of an errant vehicle.
63. **Climbing Lane.** An additional traffic lane provided for slow moving vehicles on the up-grade side of a highway.
64. **Coefficient of Utilization (CU).** The ratio of the luminous flux (lumens) from a luminaire received on the surface of the roadway to the lumens emitted by the luminaires' lamp(s) alone.

65. **Cohesionless Soil.** A soil that, when unconfined, has little or no strength when air-dried, and little or no cohesion when submerged. Sand is an example of cohesionless soil.
66. **Cohesive Soil.** A soil that when unconfined has considerable strength when air-dried and that has significant cohesion when submerged.
67. **Composite Hydrograph.** A plot of mean daily discharges for a number of years of record on a single-year time base for the purpose of showing the occurrence of high and low flows.
68. **Compressibility.** The property of a material that enables it to remain compressed after compaction.
69. **Compressive Stress.** The stress produced in a member when the forces acting on it tend to push the particles together.
70. **Concordant Flows.** Flows at different points in a river system that has the same recurrence interval or the same frequency of occurrence. This term is most often applied to flood-flows.
71. **Conservation Storage.** Storage of water for later release for useful purposes (e.g., municipal water supply, power, irrigation) in contrast with storage capacity used for flood control.
72. **Consistency.** The degree of cohesiveness or resistance to movement of constituent particles in a mass of material. Some of the terms used to express consistency are firm, hard, friable (easily crumbled), sticky or soft.
73. **Construction Survey.** A survey executed to locate or lay out engineering works. In highway construction applications, this survey is used to set grading elevation stakes, reference points, slope stakes and other such controls.
74. **Contour.** A line that depicts equal elevation on a land surface. The line representing this on a map.
75. **Contour Grading Plan.** A drawing showing an arrangement of contours intended to integrate construction and topography, improve appearance, reduce erosion and improve drainage.
76. **Contour Interval.** The elevation difference between adjacent contours.
77. **Contract Document Hierarchy.** There are five essential parts to a contract and a requirement occurring in one is as binding as if occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of discrepancy, numerical dimensions will prevail over scaled dimensions and the parts of the contract will prevail in the following order:
- Contract Clauses, [48 CFR, Chapters 1 and 12](#);
 - Special Contract Requirements;

- Plans;
 - Supplemental Specifications; and
 - [Standard Specifications \(FP-XX\)](#).
78. **Contraction.** The reduction of a cross sectional area of a stream channel.
79. **Control.** A section or reach of an open conduit or steam channel that maintains a stable relationship between stage and discharge.
80. **Control Data.** The horizontal and vertical values used to define the relative position of a control point.
81. **Control Point.** An established point on the ground with known horizontal and vertical positioning. In highway surveying, this point is generally of second order accuracy. This point is normally used as a basis for gathering field measurements and placing construction stakes.
82. **Control Survey.** A survey made to establish the horizontal and vertical positions of a series of control points. In highway applications, a control survey is generally the first survey performed on a project. Other aspects of the surveying process base their measurements on the control points established during the control survey.
83. **Conveyance.** A measure of the carrying capacity of a stream or channel.
84. **Cooperator.** A State or local government agency that has jurisdiction over and/or maintenance responsibility for forest highways. ([FAPG 23 CFR 660 A](#))
85. **Coordinates.** A set of numbers used in describing the location of a point on a surface or in space.
86. **Corridor.** A strip of land between two termini within which traffic, topography, environment and other characteristics are evaluated for transportation purposes.
87. **Crash Cushion (Impact Attenuator).** A device placed in front of a fixed roadside object to absorb and dissipate collision energy.
88. **Creep.** The slow movement of a material under stress, usually imperceptible except to observations of long duration.
89. **Crest Vertical Curve.** A vertical curve having a convex shape in profile.
90. **Critical Flow.** The flow in open channels at which the energy content of the fluid is at a minimum. Also, that flow which has a Froude number of one.
91. **Critical Length of Grade.** That combination of gradient and length of grade that will cause a designated vehicle to operate at some predetermined minimum speed.
92. **Critical Slope.** The gradient of a channel that sustains a given discharge at a uniform and critical depth. A grade less than critical is called a mild grade or slope whereas a steeper than critical slope is called a steep slope.

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93. **Critical Velocity.** The velocity in an open channel or a partially filled conduit where the velocity head equals one-half the hydraulic mean depth.
94. **Cross Section.** The transverse profile of a road showing horizontal and vertical dimensions.
95. **Crosswalk.** Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by signs and by lines or other markings on the surface.
96. **Crossing Sight Distance.** A distance along an intersection approach leg such that vehicle operators can see other vehicles on crossroads in time to avoid collision.
97. **Crown.** The highest point of the surface of a tangent traveled way in cross section.
98. **Crushed Gravel.** The product resulting from the crushing of ordinary gravel with substantially all fragments having one or more faces resulting from fracture.
99. **Crushed Stone.** The product resulting from the crushing of fragments of bedrock or large stones with all fragments having all faces resulting from fracture.
100. **Cubic Meters Per Second (m³/s).** A unit expressing rates of discharge. One cubic meter per second is equal to the discharge of a stream of rectangular cross section (one meter wide by one meter deep) that is flowing water at one meter per second.
101. **Culture or Cultural Features.** General term used in mapping to describe manmade features.
102. **Culvert.** Any structure that provides an opening under the roadbed but does not meet the classification of a bridge.
103. **Curb.** A structure with a vertical or sloping face placed on roadways to form islands, gutters, etc. and to protect pavement edges.
104. **Current Meter.** An instrument for measuring the speed of flowing water.
105. **Curve Widening.** The widening of the highway traveled way on sharp curves to compensate for the fact that the rear wheels of a vehicle do not follow exactly in the track of the front wheels.
106. **Curvilinear Alignment.** A flowing alignment in which the majority of its length is composed of circular and spiral curves.
107. **Data Collector.** A recording device that electronically records surveying measurements and field notes. The information stored in these collectors is downloaded into a computer for later processing.
108. **Datum Plane.** A reference plane to which vertical measurements and elevations are referred. Usually the datum plane (elevation 0.000) used is mean sea level.
109. **Dead Storage.** The volume in a reservoir below the lowest controllable level.

110. **Deadman.** A buried object serving as an anchor (e.g., a cable-guardrail guy anchors).
111. **Deceleration Lane.** A speed-change lane that enables a vehicle to slow to a safe exit speed when making an exit turn.
112. **Decibel (Db).** The unit for measuring the intensity of sound. When A-weighting is used, this unit is abbreviated as dBA.
113. **Deciduous.** Having leaves that are shed at the end of the growing season; opposite of evergreen.
114. **Degradation.** General and progressive lowering of the longitudinal profile of a channel by erosion.
115. **Delineator.** A visual device for defining the alignment of a roadway.
116. **Dense Graded.** A well-graded aggregate with sufficient fine material to nearly fill all voids.
117. **Depletion.** The progressive withdrawal of water from surface or ground water reservoirs at a rate greater than that of replenishment. (See recession curve and streamflow depletion.)
118. **Depression Storage.** The volume of water contained in natural depressions in the land surface (e.g., puddles).
119. **Design Capacity.** The practical capacity or lesser value determined for use in designing the highway to accommodate the design volume.
120. **Design Discharge.** The discharge that a culvert is designed to pass. This discharge depends on the recurrence interval of the design flood, which, in turn, depends on the importance of the road and the characteristics of the watershed.
121. **Design Headwater.** The elevation of culvert inlet ponding above the culvert invert, for a given storm interval, culvert type, size and discharge.
122. **Design Hourly Volume (DHV).** The future two-way hourly traffic volume for use in design, usually the 30th highest hourly volume of the design year (30 HV).
123. **Design Lane.** The lane on which the greatest number of equivalent 80 kN (18,000 lbs), single-axle loads is expected.
- Normally, this will be either lane of a two-lane highway or the outside lane of a multilane highway.
124. **Design Load.** The loads that must be supported by a structure.
125. **Design Noise Levels.** The noise levels that represent the upper limit of acceptable traffic noise established for various activities or land uses. These levels are used to determine the degree of impact of traffic noise on human activities.

126. **Design Speed.** A speed selected for purposes of design and correlation of the geometric features of a highway and a measure of the quality of service offered by the highway. It is the highest continuous speed where individual vehicles can travel with safety upon a highway when weather conditions are favorable, traffic density is low and the geometric design features of the highway are the governing conditions for safe speed.
127. **Design Thickness.** The total thickness of the pavement structure determined from the thickness design charts as adequate for a given total 80 kN (18,000 lbs) equivalent single-axle loads soil strength value.
128. **Design Vehicle Turning Radius.** The turning radius of a design vehicle used primarily to determine the minimum radius used in the design of turning and intersecting roadways.
129. **Design Year.** The future year used to estimate the probable traffic volume for which a highway is designed. A time ten to 20 years from the start of construction is usually used.
130. **Dike.** An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of low lands or to deflect water away from a bank. Also called levee.
131. **Dike, Finger.** Relatively short embankments constructed normal to a larger embankment (e.g., an approach fill to a bridge). Their purpose is to impede flow and direct it away from the major embankment.
132. **Dike, Spur.** Relatively short embankments constructed at the upstream side of a bridge end for the purpose of aligning flow with the waterway opening and to move scour away from the bridge abutment.
133. **Dike, Toe.** Embankments constructed to prevent lateral flow from scouring the corner of the downstream side of an abutment embankment. Sometimes referred to as training dikes.
134. **Dike, Training.** Embankment constructed to provide a transition from the natural stream channel or floodplain, both to and from a constricting bridge crossing.
135. **Dip (Low-Water Crossing).** A road stream crossing designed to allow occasional flooding. The road grade is lowered to stream bed level from bank-to-bank.
136. **Direct Runoff.** The runoff entering stream channels promptly after rainfall or snowmelt. Superposed on base runoff, it forms the bulk of the hydrograph of a flood. See also surface runoff. The terms base runoff and direct runoff are time classifications of runoff. The terms ground-water runoff and surface runoff are classifications according to source.
137. **Direct Shear Test.** A shear test in which soil under an applied normal load is stressed to failure by moving one section of the soil container relative to the other section.

138. **Discharge.** The flow of water from a pipe, drain system or drainage basin.
139. **Discharge Frequency.** The runoff that can be expected to occur during the life of a highway. Design may be on a 10, 25, 50 or 100-year flood.
140. **Discharge Rating Curve.** See [stage-discharge relation](#).
141. **Diversión.** The taking of water from a stream or other body of water into a canal, pipe or other conduit.
142. **Divided Highway.** A highway with separated roadways for traffic in opposite directions.
143. **Divisional Island.** A longitudinal island to separate opposing traffic, to provide protection for left turn bays and to channel traffic into the proper approach paths at skewed intersections.
144. **Dormant Stage.** The period in plant life when seasonal growth ceases.
145. **Drainage Area.** The drainage areas of a stream at a specified location in that area measured in a horizontal plane and enclosed by a drainage divide.
146. **Drainage Basin.** The part of the surface of the earth that is occupied by a drainage system consisting of (1) a surface stream or (2) a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.
147. **Drainage Divide.** The rim of a drainage basin.
148. **Drawdown.** The difference in elevation between the water surface elevation at a constriction in a stream or conduit and the elevation that would exist if the constriction were absent. Drawdown also occurs at changes from mild to steep channel slopes and at weirs or vertical spillways.
149. **Driveways.** Minor roadway connections that fall into three categories:
- private,
 - commercial, and
 - public.
150. **Dune.** A sand wave of approximately triangular cross section (in a vertical plane in the direction of flow) formed by moving water or wind, with gentle upstream slope and steep downstream slope. Dunes travel downstream by the movement of sediment on the upstream slope and deposition on the downstream slope.
151. **Dynamic Equilibrium.** That delicate balance of the many factors that must occur in a stream reach so that the channel is neither aggrading nor degrading.
152. **Ecology.** The branch of science concerned with the relationship of organisms and their environment.
153. **Effluent.** Sewage, water or other liquid, partially or completely treated or in its natural state flowing out of a reservoir, basin or treatment plant.

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154. **Elastic Limit.** The greatest stress that a material is capable of sustaining without any permanent deformation remaining upon complete release of the stress.
155. **Elasticity.** That property of a material that permits it to return approximately to its original dimensions upon the removal of an applied load.
156. **Electronic Distance Measuring Instrument (EDM).** A device that transmits and receives a modulated microwave, infrared or visible light signal and, by measuring phase differences between modulations of transmitted and reflected or retransmitted signals, computes the distance between the instrument and the reflector or retransmitter.
157. **Elevation.** The vertical distance of a point above mean sea level or above another datum.
158. **Elongation.** The increase in gage length of a tension test specimen, usually expressed as a percentage of the original gage length.
159. **Embankment.** A raised earth structure on which the roadway pavement structure is placed.
160. **Embankment Foundation.** The material below the original ground surface, the physical characteristics of which affect the support of the embankment.
161. **Emergency Vehicle.** (1) A vehicle belonging to the armed forces, civil defense, police. (2) Any ambulance rescue unit vehicle. (3) Any designated vehicle used for answering emergency calls for assistance.
162. **Empirical.** Developed from experience or observations without regard to science and theory.
163. **Emulsified Asphalt.** A mixture of asphalt cement and water mixed with an emulsifying agent.
164. **Emulsified Asphalt Treated Base.** A base consisting of a mixture of mineral aggregate and emulsified asphalt spread on a prepared surface to support a surface course.
165. **Energy Dissipator.** A riprap basin or concrete structure placed at the outlet end of a culvert to dissipate the stream energy and reduce scour and erosion.
166. **Energy Grade Line.** The line that represents the total energy gradient along the channel. It is established by adding together the potential energy (water surface elevation referenced to a datum) and the kinetic energy (usually expressed as velocity head) at points along the streambed or channel floor.
167. **Entrance Loss.** The loss of energy at a culvert entrance due to the shape of the entrance.
168. **Environment.** The totality of man's surroundings (i.e., social, physical, natural, manmade).

169. **Environmental Design.** The location and design of a highway that includes consideration of the impact of the facility on the community or region based on aesthetic, ecological, cultural, sociological, economic, historical, conservation and other factors.
170. **Equivalent Single-Axle Load (EAL).** The effect on pavement performance of any combination of axle loads of varying magnitude, equated to the number of reference single-axle loads required to produce an equivalent number of repetitions of an 80 kN (18,000 lb) single axle.
171. **Erosion.** A slow wearing away of the surface by natural action of wind or water.
172. **Estuary.** That portion of a river channel occupied at times or in part by both sea and river flow in appreciable quantities. The water usually has brackish characteristics.
173. **Eutrophic.** A body of water rich in nutrients and characterized by a large quantity of planktonic algae.
174. **Evapotranspiration.** Water withdrawn from a land area by evaporation from water surfaces and moist soil and plant transpiration.
175. **Excavation.** (1) The act of taking out material. (2) The materials taken out. (3) The cavity remaining after materials have been removed.
176. **Expressway.** A multilane, divided highway designed to move large volumes of traffic at high speeds under free-flow conditions. Expressways have full control of access with grade-separated interchanges.
177. **Expropriation.** Acquisition of property for highway purposes by the right of eminent domain.
178. **Federal Lands Highway Division.** A Federal Lands Highway field office, responsible for the administration of the Federal Lands Highway program within a predetermined geographic area. See [Exhibit 1.1-A](#)
- The Eastern Federal Lands Highway Division (EFLHD) office headquartered in Sterling, Virginia.
 - The Central Federal Lands Highway Division (CFLHD) office headquartered in Denver, Colorado.
 - The Western Federal Lands Highway Division (WFLHD) office headquartered in Vancouver, Washington.
179. **Federal Lands Highway Office (FLHO).** A FHWA headquarters office located in Washington, DC with the responsibility for the direct Federal program that is administered through division field offices.
180. **Flexible Base.** A base with low resistance to bending, enabling it to stay in contact with the underlying structure. This type of base distributes loads to the subbase. Examples are dense-graded aggregate bases and asphalt-treated bases.

181. **Flexible Pavement.** A pavement structure that maintains intimate contact with and distributes loads to the subgrade, and depends on aggregate intergranular particle friction and cohesion for stability.
182. **Flood.** (1) An overflow or inundation that comes from a river or other body of water and causes or threatens damage. (2) A relatively high streamflow overtopping the natural or artificial banks in any reach of a stream. (3) A relatively high flow as measured by either gage height or discharge quantity.
183. **Flood Exceedance Probability.** Probability that a random event will exceed a specified magnitude in a given time period, usually one year unless otherwise indicated.
184. **Flood Frequency.** The average interval of time, based on the period of record, between floods equal to or greater than a specified discharge or height. Generally, this frequency is expressed in years.
185. **Flood, Maximum Probable.** The largest flood for which there is any reasonable expectancy in a given climatic era.
186. **Flood Peak.** The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge. Flood crest has nearly the same meaning, but since it connotes the top of the flood wave, it is properly used only in referring to stage; thus, crest stage, but not crest discharge.
187. **Flood Plain.** Normally dry land areas that are adjacent to a natural stream or watercourse and that are temporarily inundated during floods.
188. **Flood Routing.** The process of determining progressively the timing and shape of a flood wave at successive points along the river.
189. **Flood Wave.** A distinct rise in stage culminating in a crest and followed by recession to lower stages.
190. **Flood Zone.** The land bordering a stream that is subject to floods of about equal frequency.
191. **Floodway.** (1) A part of the floodplain, otherwise leveed, reserved for emergency diversion of water during floods. (2) A part of the floodplain which, to facilitate the passage of floodwater, is kept clear of encumbrances.
192. **Flow Line.** The bottom of a streambed, culvert, ditch or other watercourse.
193. **Flow-Duration Curve.** A cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded.
194. **Flow Regime.** The system or order characteristic of streamflow with respect to velocity, depth and specific energy.
195. **Footing.** Portion of the foundation of a structure that transmits loads directly to the soil.

196. **Foreslope.** The slope from the edge of the surfaced shoulder to the top of the subgrade or the bottom of the ditch in cuts.
197. **Foundation.** Lower part of a structure that transmits loads directly to the soil.
198. **Free Water.** Water that can move through the soil by force of gravity.
199. **Freeboard.** The vertical distance between the level of the water surface at design flow and a specified point (e.g., a bridge beam, levee top, location on a highway grade).
200. **Friable Soil.** A soil that can be easily broken and crushed by moderate finger pressure.
201. **Frontage Road.** A road contiguous to a controlled access highway, so designed as to (1) intercept, collect and distribute traffic desiring to cross, enter or leave the controlled access highway, and (2) furnish access to adjacent property.
202. **Froude Number (F_r).** A dimensionless expression of the ratio of inertia forces to gravity forces, used as an index to characterize the type of flow in a hydraulic structure in which gravity is the force producing motion and inertia the resisting force. The Froude number for critical flow is one. Values greater than one indicate supercritical flow. Values less than one indicate subcritical flow. Equation 1.4(1) applies:

$$F_r = \frac{v^2}{\sqrt{gy}} = \frac{v}{v_c} \quad (\text{Equation 1.4(1)})$$

where: g = gravity (9.81 m/s² (32.2 ft/s²))
 v = mean, surface or maximum flow velocity (m/s (ft/s))
 v_c = critical velocity for channel and discharge (m/s (ft/s))
 y = a characteristic dimension in meters (feet) (e.g., diameter, depth)

203. **Functional Classification.** The grouping of individual roads in a road system according to their purpose and the type of traffic they serve.
204. **Gage Height.** The water-surface elevation referred to by some arbitrary gage datum. Gage height is often used interchangeably with the more general term stage, although gage height is more appropriate when used with a reading on a gage.
205. **Gaging Station.** A location on a stream where measurements of stage or discharge are customarily made.
206. **Geodetic Control.** Monument points of known horizontal and/or vertical position established by other agencies and published by NGS.
207. **Geometric Design.** The arrangement of the visible elements of a road (e.g., alignment, grades, sight distance, widths, slopes).
208. **Geotechnical Engineering.** The application of scientific methods and engineering principles to the acquisition, interpretation and evaluation of subsurface data to predict the behavior of the materials of the earth's crust. It encompasses the fields of soil

- mechanics, rock mechanics, geological engineering, geophysics and related fields (e.g., pavement design).
209. **Glare.** The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted, thereby causing discomfort or loss of visibility.
210. **Global Positioning System (GPS).** A system of satellites that are used with accurate receiving equipment to determine survey coordinates.
211. **Gradation.** A general term used to describe the composition of an aggregate, soil or other granular material. Gradation is usually expressed as the proportions (percents) of the aggregate that will pass each of several sieves of different sizes.
212. **Grade.** (1) The profile of the center of the roadway or its rate of ascent or descent. (2) To shape or reshape an earth road by means of cutting or filling. (3) To arrange according to size. (4) Elevation.
213. **Grade Contour.** The trace of a predetermined grade plotted on a topographic map or traced on the ground by an Abney Level Line. For example, if the contour interval is 2 m (6.5 ft) and the gradient five percent, the grade contour intersections with successive contours would be 40 m (130 ft) apart.
214. **Grade-Controlled Location.** A section of highway where the highway route is controlled by the maximum allowable gradient and the difference in elevation between termini.
215. **Grade Intersection.** An intersection where all roadways join or cross at the same level.
216. **Grade Separation.** A structure that provides for highway traffic to pass over or under another highway or the tracks of a railroad.
217. **Gradient.** The rate of rise or fall with respect to the horizontal distance.
218. **Grading.** (1) Construction of the earthwork portion of the highway; (2) planing or smoothing the surface of various parts of a roadbed.
219. **Gradually Varied Flow.** Flow in which changes in depth and velocity take place slowly over large distances, resistance to flow dominates and acceleration forces are neglected.
220. **Gravel.** Aggregate composed of hard, durable stones or pebbles, crushed or uncrushed, often intermixed with sand.
221. **Ground Control.** An accurate ground survey of targets or other features visible in aerial photographs to ensure the accuracy of photogrammetric mapping.
222. **Ground Cover.** Herbaceous vegetation and low-growing woody plants that form an earth cover.

223. **Ground Water.** Free water contained in the zone below the water table. The source of water in wells, springs, etc.
224. **Grout.** Mortar, composed of sand, cement and water, of a consistency that it can be easily worked.
225. **Guardrail.** A protective cable or rail device placed along the roadway edge for the purpose of redirecting vehicles that have left the roadway at a point of hazard.
226. **Gunite.** A type of Portland cement mortar blown into place by compressed air. The materials are mixed while being forced through a nozzle.
227. **Gutter.** A paved and generally shallow waterway provided for carrying surface drainage.
228. **Hardpan.** A layer of extremely dense soil.
229. **Head.** The energy, either kinetic or potential, possessed by each unit mass of a liquid expressed as the vertical height through which a unit mass would have to fall to release the average energy possessed.
230. **Headcutting.** Progressive scouring and degrading of a streambed at a relatively rapid rate in the upstream direction -- usually characterized by one or a series of vertical falls.
231. **Headwall.** A wall or structure constructed at the end of a culvert to prevent earth from spilling into the channel.
232. **Headwater Depth.** Culverts constrict the natural stream flow and cause a rise in the water surface at the culvert entrance. Headwater depth is the total flow depth from the inlet invert of the culvert to the water surface at the inlet.
233. **Herbaceous.** Vegetation that is nonwoody.
234. **Hinge Point.** The point where the slope rate changes.
235. **Horizon (Soils).** One of the layers (strata) of the soil profile, distinguished principally by its texture, color, structure and chemical contents.
236. **Horizontal Curve.** A circular or transitional curve by means of which a highway can change direction to the right or left.
237. **Hot Mix.** A general term used for hot plant mixed asphalt concrete mixtures manufactured and laid at temperatures ranging from 95°C (200°F) to 160°C (320°F).
238. **Humidity (Relative).** The amount of moisture in the air compared with the amount that the air could hold if saturated at that temperature.
239. **Humus.** A brown or black material formed by the partial decomposition of vegetable or animal matter; the organic portion of soil.

240. **Hydrated Lime.** A dry powder obtained by treating quick-lime with enough water to satisfy its chemical affinity for water under the conditions of its hydration.
241. **Hydrograph.** A graph showing stage, flow, velocity or other property of water with respect to time.
242. **Hydrologic Cycle.** (1) A convenient term to denote the circulation of water from the sea, through the atmosphere, to the land; and, thence, with many delays, back to the sea by overland and subterranean routes, and in part by way of the atmosphere. (2) The many short circuits of the water that is returned to the atmosphere without reaching the sea.
243. **Hydrology.** (1) The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground and underground. (2) The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks and in the atmosphere.
244. **Igneous Rock.** Those rocks formed by the cooling and consolidation of complex silicious solutions (magma) newly risen from some deeper level.
245. **Illuminance.** The density of the luminous flux incident on a surface; it is the quotient of the luminous flux divided by the area of the surface when the latter is uniformly illuminated.
246. **Illuminance (Lux) Meter.** - An instrument for measuring the illuminance on a plane. The instrument is comprised of some form of photodetector, with or without a filter, driving a digital or analog readout through appropriate circuitry.
247. **Impact Attenuator.** A device placed in front of a fixed roadside object to absorb and dissipate collision energy.
248. **Impervious.** Resistant to the penetration of a liquid or gas.
249. **Incised Channel.** Those channels that have been cut relatively deep into underlying formations by natural processes. Characteristics include relatively straight alignment and high, steep banks so that overflow rarely occurs, if ever.
250. **Independent Alignments.** Each roadway of a divided highway is designed and located to take full advantage of the terrain. The median need not be of uniform width, and the two roadways need not be at the same level.
251. **Indigenous.** Produced, growing or living naturally in a particular region or environment.
252. **Infiltration.** The flow of a fluid into a substance through pores or small openings. It connotes flow into a substance in contradistinction to the word percolation, which connotes flow through a porous substance.
253. **Inlet Control.** A culvert operates under inlet control when the flow capacity is controlled by headwater depth, culvert cross section and inlet edge configuration.

254. **Interchange.** A system of interconnecting roadways in conjunction with one or more grade separations, providing for the movement of traffic between two or more roadways on different levels.
255. **Internal Friction.** The resistance to sliding within the soil mass.
256. **Intersection.** The area common to two or more highways that come together at an angle.
257. **Intersection Angle.** The angle between two intersection legs.
258. **Inundate.** To cover or fill, as with a flood.
259. **Invert.** The lowest point of the internal cross section of a closed conduit or channel.
260. **Isolux Line.** A line plotted on any appropriate coordinates to show all the points on a surface where the illuminance is the same. For a complete exploration, the line is a closed curve. A series of these types of lines for various illuminance values is called an isolux diagram.
261. **Karst Topography.** Irregular topography characterized by sink holes, streamless valleys and streams that disappear into the underground, all developed by the action of surface and underground water in soluble rock (e.g., limestone).
262. **Landscaping.** Enhancing the natural features of the land through the design and use of vegetation and other materials.
263. **Lane.** A portion of the traveled way providing for a single line of traffic in one direction.
264. **Left-Turn Lane.** A traffic lane within the normal surfaced width of a roadway, or an auxiliary lane adjacent to or within a median, reserved for left-turning vehicles at an intersection.
265. **Leveling Course.** The layer of material placed on an existing surface to eliminate irregularities prior to placing an overlaying course.
266. **Lime.** A general term that includes the various chemical and physical forms of quicklime, hydrated lime and hydraulic lime used for any purpose.
267. **Lithology.** A geological term dealing with the physical properties of rocks and their structure.
268. **Loam.** A mixture of sand, silt or clay, or a combination of any of these with organic matter. It is sometimes called topsoil in contrast to the subsoils that contain little or no organic matter.
269. **Loess.** A uniform windblown deposit of silty material having an open structure and relatively high cohesion due to cementation of clay or calcareous material at grain contacts.

270. **Luminaire.** A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.
271. **Luminance (L).** Luminance is the luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction expressed in candelas per square meter (square foot) (cd/m^2 (ft^2)).
272. **Mannings Equation.** An equation normally used to express the velocity of a uniform flow of water in a natural or manmade channel (i.e., culvert). See Appendix B in *HDS* publication No. 5 for Mannings equation and listing of commonly used roughness values.
273. **Matting.** Material used as a surface protector in conjunction with seeding that protects the surface until vegetation becomes established.
274. **Meander.** In connection with streams, a winding channel usually in an erodible, alluvial valley. A reverse of an S-shaped curve or series formed by erosion of the concave bank, especially at the downstream end, characterized by curved flow and alternating shoals and bank erosion. (Meandering is a stage in the migratory movement of the channel as a whole down a valley.)
275. **Meander Plugs (Clay Plugs).** Deposits of cohesive materials in old channel bendways. These plugs are sufficiently resistant to erosion to serve as essentially semi-permanent geological controls to advancing channel migrations.
276. **Meander Scroll.** Markings resembling a partly unrolled sheet of paper or having a spiral or coiled form, which have been left on a floodplain as a result of the historic migratory movement of the channel.
277. **Median.** The portion of a divided highway separating the traveled ways for traffic in opposite directions.
278. **Median Barrier.** A longitudinal system used to prevent an errant vehicle from crossing the median of a divided highway.
279. **Median Lane.** A speed-change lane within the median to accommodate left-turning vehicles.
280. **Microfilm.** A photographic process by which plans, specifications and other printed materials are greatly reduced in size for permanent storage, usually at a ratio of 24 to 1.
281. **Mineral Filler.** A fine inert mineral matter (e.g., limestone dust, portland cement) used in asphalt concrete mixtures.
282. **Minimum Turning Path.** The path of a designated point on a vehicle making its sharpest turn.
283. **Minimum Turning Radius.** The radius of the path of the outer front wheel of a vehicle making its sharpest turn.

284. **Modulus of Elasticity.** The ratio of stress to strain for a material under given loading conditions.
285. **Modulus of Rupture.** A measure of the strength of concrete when it is broken by bending.
286. **Moisture Content.** The percentage, by mass, of water contained in soil or other material, usually based on the dry mass.
287. **Monument or Reference Point.** A permanent or semi-permanent reference point set during the survey or construction of a highway so that the survey can be reestablished later.
288. **Mortar.** A mixture of cement, sand, lime/fly ash and water.
289. **Mountable Curb.** One that can be readily traversed by a moving vehicle.
290. **Muck.** An organic soil of very soft consistency.
291. **Mudflow.** A well-mixed mass of water and alluvium that, because of its high viscosity and low fluidity as compared with water, moves at a much slower rate, usually piling up and spreading over the fan like a sheet of wet mortar or concrete.
292. **Mulch.** Material placed on exposed earth to provide more desirable moisture and temperature relationships for plant growth. It is also used to control the occurrence of unwanted vegetation.
293. **National Geodetic Vertical Datum of 1929.** The average of the heights of the surface of the sea at all stages of the tides.
294. **Noise Barrier.** A barrier of earth, stone, concrete or wood placed adjacent to the highway to reduce the noise level on abutting property.
295. **Noise Level.** The sound level obtained through the use of A-weighting according to ANSI Standard 1.4. The unit of measure is the decibel (dB), commonly referred to as DBA when A-weighting is used.
296. **Nonuniform Flow.** A flow in which the velocities vary from point-to-point along the stream or conduit, due to variations in cross section, slope, etc.
297. **Normal Water Surface (Natural Water Surface).** The free surface associated with flow in natural streams.
298. **Nutrient.** Material that nourishes and promotes plant growth.
299. **Open Channel.** A natural or manmade path in which water flows with a free surface.
300. **Open Channel Flow.** Open channel flow may be uniform or nonuniform, steady or unsteady and subcritical or critical. Of these, nonuniform, unsteady and subcritical flow is the most common type of flow in open channels. However, to facilitate hydraulic computations, steady, uniform or gradually varied flow is generally assumed.

- 301. **Open-Graded Aggregate.** A graded aggregate, containing little or no fines, with a high percentage of aggregate voids.
- 302. **Operating Speed.** The highest overall speed, exclusive of stops, at which a driver can travel on a given highway under prevailing conditions without at any time exceeding the design speed.
- 303. **Optimum.** The best quantity, number or condition.
- 304. **Outlet Velocity.** The speed of flow measured at the downstream end of a culvert and is usually higher than the maximum natural stream velocity.
- 305. **Overburden.** The mass of soil that overlies a source of rock, gravel or other road material. This material is removed before the materials are quarried to avoid contamination.
- 306. **Overland Flow.** The flow of rainwater or snowmelt over the land surface toward stream channels. After it enters a stream, it becomes runoff.
- 307. **Overlaying Course (Overlay).** An asphalt surface course, either plant mixed or road mixed.
- 308. **Overlook (Scenic Overlook).** A roadside area provided for motorists to stop their vehicles primarily for viewing the scenery.
- 309. **Overpass.** A grade separation where the highway passes over an intersecting highway or railroad.
- 310. **Parcel.** A tract of private or public land of variable size required for the right-of-way for a highway.
- 311. **Passing Opportunity.** A section of two-lane highway where the clear passing sight distance allows a safe passing maneuver to be performed.
- 312. **Passing Sight Distance.** Minimum sight distance on two-lane highways that must be available to enable the driver of one vehicle to pass another safely and comfortably, without interfering with the speed of an oncoming vehicle traveling at the design speed should it come into view after the overtaking maneuver is started.
- 313. **Passive Pressure on Walls.** The horizontal pressure exerted on the front of a wall by the earth load or water, if present. Passive pressure opposes active pressure.
- 314. **Pavement Structure.** The combination of subbase, base course and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.
- 315. **Peat.** A fibrous mass of organic matter in various stages of decomposition.
- 316. **Pedestrian Crossing (Crosswalk).** An area reserved and clearly marked for the passage of pedestrians at street junctions or other locations where drivers must yield the right-of-way by stopping to enable pedestrians to cross safely.

317. **Pedestrian Overpass (Underpass).** A facility for pedestrian crossings justified by the following:
- pedestrian crossing volumes,
 - type of highway to be crossed, and
 - location of adjacent crossing facilities and predominating type and age of persons who will utilize the facility.
318. **Perception Time.** The time required by a driver to perceive that a speed change or stop is necessary.
319. **Permeability.** The properties of a soil that permit the passage of any fluid and depend on grain size, void ratio, shape and arrangement of pores.
320. **Permissible Velocity.** In stream flow, the greatest velocity that will not cause excessive erosion.
321. **Pervious.** A layer of material, through which water will move under ordinary hydrostatic pressure.
322. **pH.** A scale of numbers from 0 to 14 that indicate the acidity or alkalinity of a solution. Numbers below seven indicate acidity and numbers above seven indicate alkalinity.
323. **Phase.** A part of a signal cycle during which a specific traffic movement (and concurrent nonconflicting movements) receives the right-of-way. It includes the change and clearance intervals associated with those movements.
324. **Photoelectric Device.** Where detection is accomplished by the vehicle passing between a source of light and a photocell that is capable of distinguishing between light and lack of light.
325. **Photogrammetry.** The science and art of obtaining reliable measurements by use of photographs. It produces dimensional data for mapping, cadastral purposes, design and computation of quantities.
326. **Physiographic Region.** A geographic area whose patterns of landforms differ significantly from that of adjacent regions.
327. **Pigment.** Any substance used to impart color; specifically, an insoluble, dry coloring matter that, when mixed with a suitable medium, forms a paint.
328. **Pipe, Clay.** Pipe made of shale and fired clay; unglazed or glazed and vitrified; with or without bell; used for field drains, edge drains, culverts, sewers, etc.
329. **Pipe, Concrete.** Pipe made of concrete with or without steel reinforcement; used for culverts, sewers, etc.
330. **Pipe, Corrugated Metal.** Pipe fabricated from corrugated metal sheets, generally steel or aluminum alloy stock; used for culverts.

331. **Pipe, Corrugated Plastic.** Pipe fabricated from corrugated plastic, generally Polyethylene (PE) or polyvinylchloride (PVC), and used for culverts.
332. **Pipe, Perforated.** Pipe fabricated from metal, plastic or concrete with holes or slots on approximately one-half of the periphery and used as underdrains to drain off water trapped in the soil.
333. **Pipe, Smooth-Wall Plastic.** Pipe fabricated from plastic, generally Polyvinyl Chloride (PVC) or Acrylonitrile-Butadiene-Styrene (ABS) and without corrugations and used for underdrains, downdrains, etc.
334. **Piping.** The action of water passing through or under an embankment and carrying some of the finer material with it to the surface of the downstream face.
335. **Plane Coordinate System.** A cartographic projection that, by accepting small variations of scale, permits describing the position of points on the surface of the earth by their plane coordinates on a cylindrical or conical surface.
336. **Planimetric Map.** A map that presents horizontal but not vertical data for the features represented. Drainages, coastlines, cover and culture are usually shown.
337. **Planimetrics.** All features both manmade and natural of significant value to the design of a proposed highway.
338. **Plans (Drawings).** The approved plans (drawings), profiles, typical cross sections, working drawings and supplemental drawings, or exact reproductions thereof that show the location, character, dimensions and details of the work.
339. **Point Bars.** Point bars are deposits of sediment that occur on the convex side or inside of channel bends. Their shape may vary with changing flow conditions, but they do not move relative to the bends.
340. **Poised Stream** (also Graded Stream). A term used by river engineers as applying to a stream that over a period of time is neither degrading nor aggrading its channel. A stream nearly in equilibrium as to sediment transport and supply.
341. **Pollution.** Contamination of any component of the total environment by harmful substances, sounds, smells or sights degrading or injurious to humans and other living organisms.
342. **Pool.** A small and rather deep body of quiescent water (e.g., as a pool in a stream).
343. **Porous.** Having many small openings, through which liquids may pass.
344. **Portable Traffic Control Signal.** A signal that is designed to be moved as a unit to the site and be operated for a limited time. (It normally consists of the necessary signal faces on poles attached to moveable bases, a control unit, the necessary electrical cables and a power supply).

345. **Portland Cement.** Hydraulic cement consisting of compounds of silica, lime and alumina; so called from its resemblance in color, when set, to the Portland stone of England.
346. **Precision.** The variance of repeated measurements of a characteristic from their average.
347. **Prestressed Concrete (Pretensioned).** Reinforced concrete in which base, wires or cables are held in a stretched condition during placing of the plastic concrete until the concrete has hardened. Then as the tension on the reinforcing steel is released, it compresses the concrete.
348. **Prestressed Concrete (Post-tensioned).** Reinforced concrete in which the prestressing wires or tendons are placed in tubes before the concrete is cast. After the concrete has hardened, the wires or tendons are stretched to a predetermined tension by jacking and are wedged in this position. The tubes may also be pressure-grouted.
349. **Prime Coat.** An asphalt material applied to an absorbent surface, preparatory to any subsequent treatment, for the purpose of hardening or toughening the surface and promoting adhesion between it and the superimposed construction.
350. **Profile.** A longitudinal section of a highway, drainage course, etc.
351. **Profile Grade.** The trace of a vertical plane intersecting a particular surface of the proposed road construction located as shown on the plans; usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.
352. **Radial Survey.** A method of ground surveying in which the instrument is placed on a point of known horizontal and vertical position and all required features are located by direction, distance and elevation difference from the instrument point.
353. **Railroad Grade Crossing.** The intersection of a highway and a railroad at the same elevation.
354. **Rapidly Varied Flow.** Flow in which changes in depth and velocity take place over short distances, acceleration forces dominate and energy loss due to friction is minor.
355. **Reach.** A length of a stream channel or shore.
356. **Reaction Time.** The time required for a driver to apply foot pressure to the brake after perception that a stop must be made.
357. **Reclamation.** The restoration of borrow and aggregate pits to a natural form that may include replacement of topsoil and vegetation (seeding).
358. **Recurrence Interval (Return Period).** The average interval of time within which the given flood will be equaled or exceeded once.
359. **Refuge Island.** (1) An island in a wide intersection to provide refuge for pedestrians. (2) A place for transit passengers to load and unload from a bus.

360. **Regime.** The system or order characteristic of a stream; its behavior with respect to velocity and volume, form of and changes in channel, capacity to transport sediment, amount of material supplied for transportation, etc.
361. **Regional Factor.** A numerical factor expressed as a summation of the values assigned for precipitation, elevation and drainage. This factor is used to adjust the structural number.
362. **Reinforced Concrete.** Concrete where steel reinforcement is embedded so that the steel and concrete act together in resisting stress.
363. **Residential Area.** That portion of a municipality or an area within the influence of a municipality in which the dominant land use is residential development, but where small business areas may be included.
364. **Rest Area.** A roadside area with parking facilities separated from the roadway providing motorists with opportunities to stop and rest for short periods.
365. **Resurfacing.** The placing of one or more new courses on an existing surface.
366. **Reverse Curve.** A curve consisting of two arcs of the same or different radii curving in opposite directions and having a common tangent or transition curve at their point of junction.
367. **Riffle-Pool Ratio.** The sum of the riffle lengths divided by the sum of the pool lengths expressed in percent for a given reach. These lengths are usually measured at a relatively low stage.
368. **Right-of-Way (R/W).** (1) Land generally publicly owned, acquired for and devoted to transportation purposes. (2) The privilege of the immediate use of the highway. The right of one vehicle or pedestrian to proceed in a lawful manner in preference to another vehicle or pedestrian.
369. **Right-Turn Lane.** An auxiliary lane or designated lane provided at grade intersections for right-turn movements.
370. **Riparian.** Pertaining to the banks of a stream.
371. **Ripple.** (1) The light fretting or ruffling of the water surface caused by a freeze. (2) Undulating ridges and furrows or crests and troughs formed by action of the flow.
372. **Riprap.** A protective covering of graded stones, with or without mortar, to prevent erosion.
373. **Road (Highway).** A general term denoting a public way for purposes of vehicular travel including the entire area within the right-of-way.
374. **Road Approaches.** Rural and suburban minor connections to a highway or frontage road from adjoining properties. These approaches can be private, public or commercial.

375. **Roadbed.** The graded portion of a road or highway (usually considered as the area between the intersection of top and side slopes) upon which the base course, surface course, shoulders and medians are constructed; the top of the subgrade.
376. **Road Mix.** A method of combining surfacing materials (e.g., mineral aggregate combined with liquid asphalt) in which the materials are mixed on the road using discs, harrows, blades or other approved means.
377. **Roadside.** That portion of the right-of-way outside the roadway.
378. **Roadside Barrier.** A longitudinal system used to shield vehicles from hazards on the roadside.
379. **Roadside Development (Roadside Enhancement).** Treatment of the roadside to (1) conserve, enhance and effectively display the natural beauty of the landscape through which the highway passes; (2) provide safety, utility, economy and highway-related recreation facilities by means of proper location, design, construction and maintenance of highways.
380. **Roadside Hazards.** The following are all potential roadside hazards for out-of-control vehicles:
- embankments;
 - ditches and rock cut slopes;
 - fixed objects (e.g., trees, boulders, drainage structures, signs, bridge parapets, barrier ends, poles);
 - side road intersections; and
 - narrow medians.
381. **Roadway.** The portion of a highway, including shoulders, for vehicular use. (A divided highway has two or more roadways.)
382. **Roughness Coefficient (n).** A coefficient used in Manning's formula to estimate the time it will take for rainwater to flow overland to the nearest watercourse. A low roughness coefficient for a watershed results in a rapid concentration of water from that watershed.
383. **Rounding.** The removal of the angle where cut and fill slopes intersect the natural ground, and the substitution of a gradual transition or rounded surface.
384. **Rumble Strip.** A rough textured surface, constructed for the purpose of causing the tires of a motor vehicle driven over it to vibrate audibly as a warning to the drivers.
385. **Runoff.** That part of the precipitation that appears in surface streams. It is the same as stream flow unaffected by artificial diversions, storage or other works of man in or on the stream channels.

386. **Sag Vertical Curve.** A vertical curve having a concave shape in profile.
387. **Scale.** The ratio of the size of the image or representation of an object on a map or photograph to its true size. Scale may be expressed as a representative fraction (1/10,000) or ratio (1:10,000) or as the number of meters (feet) on the ground represented by 1 m (1 ft) of the map or photograph (1 m to 1000 m (1 ft to 1000 ft) or 1:1000).
388. **Scour.** The result of erosive action of running water primarily in streams, excavating and carrying away material from the bed and banks.
389. **Scour, General.** The removal of material from the bed and banks across all or most of the width of a channel, as a result of a flow contraction which causes increased velocities and bed shear stress. Also known as Contraction Scour.
390. **Scour, Local.** Removal of material from the channel bed or banks that is restricted to a minor part of the width of a channel. This scour occurs around piers and embankments and is caused by the actions of vortex systems induced by the obstructions to the flow.
391. **Scour, Natural.** Removal of material from the channel bed or bank that occurs in streams with the migration of bed forms, shifting of the thalweg and at bends and natural contractions.
392. **Screening.** The use of trees, shrubs, fences or other materials to obscure an objectionable view or to reduce an objectionable sound.
393. **Seal Coat.** An asphalt coating, sometimes with cover aggregate, applied to the surface of a pavement for the purpose of waterproofing and preserving the surface, altering the surface texture of the pavement or providing resistance to traffic abrasion.
394. **Sediment.** Fragmentary material that originates from weathering of rocks and is transported by, suspended in, or deposited by water.
395. **Sedimentation.** The action or process of depositing particles of waterborne or windborne soil, rock or other materials.
396. **Sediment Discharge.** The rate at which dry mass of sediment passes a section of a stream or is the quantity of sediment, as measured by dry mass or by volume that is discharged in a given time.
397. **Seiche.** An oscillation of the water surface of a lake or other large landlocked body of water due to unequal atmospheric pressure, wind, landslides and earthquakes, or other causes, which sets the surface in vibration. Also associated with hurricanes on waters that are not landlocked.
398. **Seismic Wave.** A gravity wave caused by an earthquake.
399. **Service Road.** A road, generally unimproved, used to transport personnel, materials or equipment for the operation or maintenance of utilities located on a highway right-of-way.

400. **Serviceability.** A concept where pavements are judged on their ability to serve traffic. Longitudinal smoothness is a primary factor in this judgment.
401. **Shoaling.** Deposition of alluvial material resulting in areas with relatively shallow depth.
402. **Shoulder.** The portion of the roadway contiguous to the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.
403. **Shrub.** A small, woody multi-stemmed plant.
404. **Side Slopes.** Slopes along the side of the roadway identified by their distance from the traveled way, their slope rate and their height.
405. **Sidewalk.** That portion of a street or highway between the curb line or edge of the roadway, and the adjacent right-of-way line constructed specifically for pedestrians.
406. **Sight Distance.** The length of roadway ahead, visible to the driver.
407. **Signal System.** A system of visual signals used to control the movement of traffic, usually on city streets.
408. **Silt.** Material passing a 75-mm (3-in) sieve that is non-plastic or very slightly plastic, and exhibits little or no strength when air dried.
409. **Site Map.** A large-scale map of a specific small area (e.g., bridge site).
410. **Skew.** Oblique, not at right angles.
411. **Skew Angle.** The complement of the acute angle between two centerlines that cross.
412. **Sliver Fill.** A thin embankment slope that is roughly parallel to the natural slope of the hillside. Sliver fills that are very high in proportion to their thickness, are difficult to compact and should be avoided.
413. **Slope.** Any ground whose surface creates an angle with the plane of the horizon.
414. **Slope Rate.** The steepness of the slope — usually the ratio of the vertical change divided by the horizontal distance.
415. **Slump.** The measure of the consistency of portland cement concrete by consolidating in a slump cone, removing the cone and allowing the concrete to settle under its own mass.
416. **Soil.** Sediments or other unconsolidated accumulation of solid particles produced by the natural physical and chemical disintegration of rocks, and which may or may not contain organic matter.
417. **Soil Classification.** The arrangement of soils into classes according to their physical properties.

418. **Soil Stabilization.** Measures taken to eliminate or minimize the erosion of soil or to improve its supporting capacity.
419. **Spalling.** Chipping along the edges, as at joints in concrete pavement and structures.
420. **Specific Energy.** The energy contained in a stream of water, expressed in terms of head, referring to the bed of a stream. It is equal to the mean depth of water plus the velocity head of the mean velocity.
421. **Specifications.** The compilation of provisions and requirements for the performance of the prescribed work.
- [Standard Specifications](#). The book of Standard specifications for construction of roads and bridges on Federal Highway projects issued periodically and designated as FP-XX (e.g., FP-03, or simply FP).
 - Supplemental Specifications. Approved additions and revisions to the *Standard Specifications* issued by the Federal Lands Highway Office (FLHO).
 - Special Contract Requirements (SCR). Additions and revisions to the *Standard Specifications* and Supplemental Specifications applicable to individual projects and generally issued by the applicable Federal Lands Highway Division offices.
422. **Spillway.** A surface apron or trough for conducting water down a relatively steep slope.
423. **Stabilization.** Modification of soils or aggregates by incorporating materials that will increase load-bearing capacity, firmness and resistance to weathering or displacement.
424. **Stage.** The height of a water surface above an established datum plane; also gage height.
425. **Stage Construction.** The construction of a highway by stages or increments.
426. **Stage-Discharge Curve (Rating Curve).** A graph showing the relation between the gage height (usually plotted as ordinate) and the amount of water flowing in a channel (expressed as volume per unit of time and plotted as abscissa).
427. **Standard.** Something having recognized and usually permanent values and established as a model or criteria.
428. **Standard Drawings.** Drawings issued by the Federal Lands Highway Office and approved for repetitive use.
429. **Standing Wave.** A term that when used to describe the upper flow regime in alluvial channels means a vertical oscillation of the water surface between fixed nodes without appreciable progression in either an upstream or downstream direction. To maintain the fixed position, the wave must have a celerity (velocity) equal to the approach velocity in the channel, but in the opposite direction.

430. **Station.** (1) A measure of distance used for highways and railroads. A station is equal to 100 m (100 ft). (2) A precise location along a survey line.
431. **Steady Flow.** A flow in which the flow rate or quantity of fluid passing a given point per unit of time remains constant.
432. **Stereoplotter.** A photogrammetric instrument (often simply called a plotter) used for measuring and mapping from aerial photographs. The instrument provides analogical solutions for object point positions from their corresponding image positions on overlapping pairs of photographs. The primary use of stereoplotters is in the compilation of topographic maps and digital terrain models.
433. **Stockpass.** A culvert of a size large enough for the passage of domestic and wild animals.
434. **Stone.** Rock material produced from a quarry (i.e., nongravel material).
435. **Stop Line.** A white line placed transversely on the pavement (at an intersection) to indicate where the vehicle must stop when obeying a traffic signal or stop sign.
436. **Stopping Sight Distance.** The distance required by a driver of a vehicle, traveling at a given speed, to bring the vehicle to a stop after an object on the roadway becomes visible. It includes the distance traveled during the perception and reaction times, as well as the vehicle braking distance.
437. **Storage.** (1) Water artificially impounded in surface or underground reservoirs for future use. The term regulation refers to the action of this storage in modifying stream flow. See also [conservation storage](#) and [dead storage](#). (2) Water naturally detained in a drainage basin (e.g., groundwater, channel storage, depression storage). The term drainage basin storage or simply basin storage is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin.
438. **Storm Drain.** A system of catch basins and underground conduits for collecting, concentrating and conveying water to a disposal point.
439. **Stratigraphy.** The study of rock strata, generally by analyzing rock outcrops or drill cores.
440. **Stream.** A general term for a body of flowing water. In hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally as in the term stream gaging, it is applied to the water flowing in any channel, whether natural or artificial. Streams in natural channels may be classified as follows:
- a. **Relation to Time.** The following applies:
- i. *Perennial.* One that flows continuously.
 - ii. *Intermittent or Seasonal.* One that flows only at certain times of the year when it receives water from springs or from some surface source (e.g., melting snow in mountainous areas).

- iii. *Ephemeral*. One that flows only in direct response to precipitation, and whose channel is at all times above the water table.

b. Relation to Space. The following applies:

- i. *Continuous*. One that does not have interruptions in space.
- ii. *Interrupted*. One that contains alternating reaches that are perennial, intermittent or ephemeral.

c. Relation to Ground water. The following applies:

- i. *Gaining*. A stream or reach of a stream that receives water from the zone of saturation.
- ii. *Losing*. A stream or reach of a stream that contributes water to the zone of saturation.
- iii. *Insulated*. A stream or reach of a stream that neither contributes water to the zone of saturation nor receives water from it. It is separated from the zones of saturation by an impermeable bed.
- iv. *Perched*. A perched stream is either a losing stream or an insulated stream that is separated from the underlying groundwater by a zone of aeration.

441. **Stream-Gaging Station.** A gaging station where a record of discharge of a stream is obtained. Within the Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained.

442. **Stream Order.** A method of numbering streams as part of a drainage basin network. The smallest unbranched mapped tributary is called first order, the stream receiving the tributary is called second order, and so on. It is usually necessary to specify the scale of the map used. A first-order stream on a 1:50,000 (1:62,500) map, may be a third-order stream on a 1:10,000 (1:12,000) map. Tributaries that have no branches are designated as of the first order; streams which receive only first-order tributaries are of the second order; large branches which receive only first-order and second-order tributaries are designated third order; and so on, with the main stream being always of the highest order.

443. **Stream Power.** An expression used in predicting bed forms and hence bed load transport in alluvial channels; the product of the mean velocity, the specific weight of the water sediment mixture, the normal depth of flow and the slope.

444. **Stream Response.** Changes in the dynamic equilibrium of a stream by one or a combination of various causes.

445. **Stress-Strain Diagram.** A diagram where corresponding values of the stress and strain are plotted.

446. **Subbase.** The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course.
447. **Subcritical Flow.** Flow with a Froude number less than one. At subcritical flow, the role played by gravity forces is more pronounced, so the flow has low velocity and is often described as tranquil and streaming.
448. **Supercritical Flow.** Flow with a Froude number greater than one. At supercritical flow, the inertia forces become dominant, so the flow has a high velocity and is usually described as rapid, shooting and torrential.
449. **Superelevation.** The elevation of the outside edge of a curve to partially offset the centrifugal force generated when a vehicle rounds the curve.
450. **Superelevation (Water).** The increase in water surface elevation at the outside of open channel bends.
451. **Superelevation Runoff.** The transition distance between normal crown and fully superelevated roadway.
452. **Surface Course.** One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion and the disintegrating effects of climate. The top layer is sometimes called wearing course.
453. **Surface Treatment.** An application of asphalt material and cover aggregate.
454. **Suspended Load.** Sediment that is supported by the upward components of turbulent currents in a stream and that stays in suspension for an appreciable length of time.
455. **Sustained Grade.** A continuous highway grade of appreciable length and consistent or nearly consistent gradient.
456. **Tack Coat.** An application of asphalt material to an existing surface to provide bond with a superimposed course.
457. **Tailwater Depth.** This is the flow depth in the downstream channel measured from the invert at the culvert outlet to the water surface.
458. **Target (Aerial).** A contrasting symmetrical pattern centered around a point on the ground to facilitate locating and measuring to the image of the point in a photograph.
459. **Terrace.** A berm, or discontinuous segments of a berm, in a valley at some height above the flood plain and representing a former abandoned flood plain of the stream.
460. **Terrain.** The physical features of a tract of land, geographic area or territory.
461. **Thalweg.** The line following the lowest part of a valley, whether under water or not. Usually the line following the deepest part of the bed or channel of a river.
462. **Time of Concentration.** The time required for water to flow from the farthest point on the watershed to the gaging station.

463. **Toe of Slope.** The intersection of a roadway embankment side slope with the original ground surface.
464. **Topographic Map.** A planimetric map with an added expression of topography, usually contours.
465. **Topographic Survey.** A survey conducted to determine the configuration of the ground.
466. **Topsoil.** A surface soil that is predominately a loose, friable, free draining sandy loam, which is free of subsoil, refuse, stumps, roots and rocks larger than 50 mm (2 in) in diameter, but containing some organic matter.
467. **Tortuous Channel.** A winding channel that is not free of shift in its alignment.
468. **Total Station.** A vertical and horizontal angle-measuring theodolite with an electronic distance measuring instrument attached to or integral with the theodolite's telescope. The theodolite generally has the ability to convert angular measurements into a digital form. Such theodolites display the slope and horizontal distance as well as the elevation difference between the instrument point and a remote point. Some models are able to retain horizontal coordinates. Often a data-recording device is offered as optional equipment.
469. **Traffic Actuated Signal.** A type of traffic control signal in which the length of most intervals and the cycle and, in some types the sequence of phasing, are varied by the demands of traffic.
470. **Traffic Barriers.** Roadside barriers, median barriers, crash cushions and bridge parapets intended to guide or protect traffic from roadside hazards, including collision with other vehicles.
471. **Traffic Control Devices.** Signs, signals, markings and devices placed or erected for the purpose of regulating, warning or guiding traffic.
472. **Traffic Island.** An island provided in the roadway to separate or direct streams of traffic; includes both divisional and channelizing islands.
473. **Traffic Lane.** That portion of the traveled way for the movement of a single line of vehicles.
474. **Traffic Markings.** A traffic control device consisting of lines, patterns, words, symbols or colors on the pavement.
475. **Traffic Noise Impacts.** Impacts that occur when the predicted traffic noise levels approach or exceed the design noise levels, or when the predicted traffic noise levels substantially exceed the existing noise levels.
476. **Traffic Volume.** The number of vehicles passing a given point during a specific period of time.
477. **Transition.** A section of variable pavement width required when changing from one width of traveled way to a greater or lesser width.

478. **Transition Curve (Spiral).** A curve of variable radius intended to effect a smooth transition from tangent to curved alignment.
479. **Transverse.** At right angle to the longitudinal direction.
480. **Traveled Way.** The portion of the roadway for the movement of vehicles, exclusive of shoulders.
481. **Traverse.** In surveying, a series of interconnected straight lines. The lengths of the lines and the angles of deviation between them are measured as the traverse develops.
482. **Triaxial Shear Test.** A test in which a cylindrical specimen of soil, encased in an impervious membrane, is subject to a confining pressure and then loaded axially to failure.
483. **Trigonometric Leveling.** Determining elevation difference by measuring the slope distance, vertical angle and difference in instrument heights between two points.
484. **Turning Track Width.** The radial distance between the turning paths of the outside of the outer front tire and the outside of the rear tire that is nearest the center of the turn.
485. **Underdrain.** Porous or perforated pipe or graded aggregate installed under a roadway or shoulder to provide subsurface drainage.
486. **Underpass.** A grade separation where the highway passes under an intersecting highway or railroad.
487. **Uniform Flow.** Flow in which the velocities are the same in both magnitude and direction from point-to-point along the stream or conduit, all stream lines being parallel.
488. **Unit Hydrograph.** (1) The hydrograph of direct runoff from a storm uniformly distributed over the drainage basin during a specified unit of time; the hydrograph is reduced in vertical scale to correspond to a volume of runoff of 25 mm (1 in) from the drainage basin. (2) The hydrograph of surface runoff (not including groundwater runoff) on a given basin due to an effective rain falling for a unit of time.
489. **Unsteady Flow.** A flow in which the velocity changes with respect to both space and time.
490. **Vertical Curve.** A curve on the longitudinal profile of a road to provide for change of gradient.
491. **Vista.** A distant view seen from a highway. A moving vista is a view observed from a moving vehicle. A stationary vista is a view seen from a fixed place (e.g., rest area, scenic overlook).
492. **Washload.** That part of the total sediment discharge that is composed of particle sizes finer than those found in appreciable quantities in the bed material.
493. **Water-Cement Ratio.** The ratio of the mass of water, exclusive only of that absorbed by the aggregates, to the mass of cement in a concrete or mortar mixture.

494. **Water Course.** A natural or artificial channel in which a flow of water occurs, either continuously or intermittently. Natural water courses may be either on the surface or underground.
495. **Water Table.** The top of the zone of permanent soil saturation. The water table may rise or fall seasonally, or it may be drawn down by removal of water.
496. **Water Year.** In Geological Survey reports dealing with surface-water supply, the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes nine of the 12 months. Thus, the water year ending on September 30, 1959, is called 1959 water year.
497. **Watershed.** In the past, the term watershed was used to mean the divide separating one drainage basin from another. However, over the years, use of the term to signify drainage basin or catchment area has come to predominate, although drainage basin is preferred. Drainage divide or just divide, is used to denote the boundary between one drainage area and another. Used alone, the term “watershed” is ambiguous and should not be used unless the intended meaning is made clear.
498. **Weathering.** The decomposition of rock, shale, etc., resulting from any chemical or mechanical process caused by exposure to weather.
499. **Weephole.** A hole through an abutment or retaining wall to relieve hydrostatic pressure.
500. **Working Drawings.** Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel or any other supplementary plans or similar data.

1.5 (RESERVED)

1.6 (RESERVED)

1.7 DIVISION PROCEDURES

Reserved for Federal Lands Highway Division office use in supplementing the policy and guidelines set forth in this Chapter with appropriate Division procedures and direction.

1.7.1 EFLHD Procedures

1.7.2 CFLHD Procedures

1.7.3 WFLHD Procedures